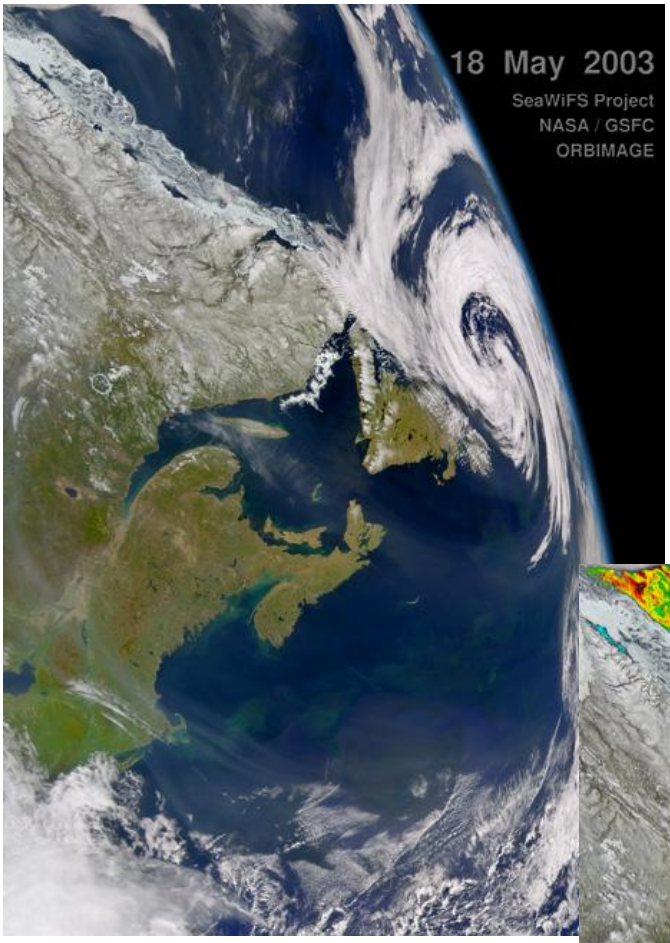
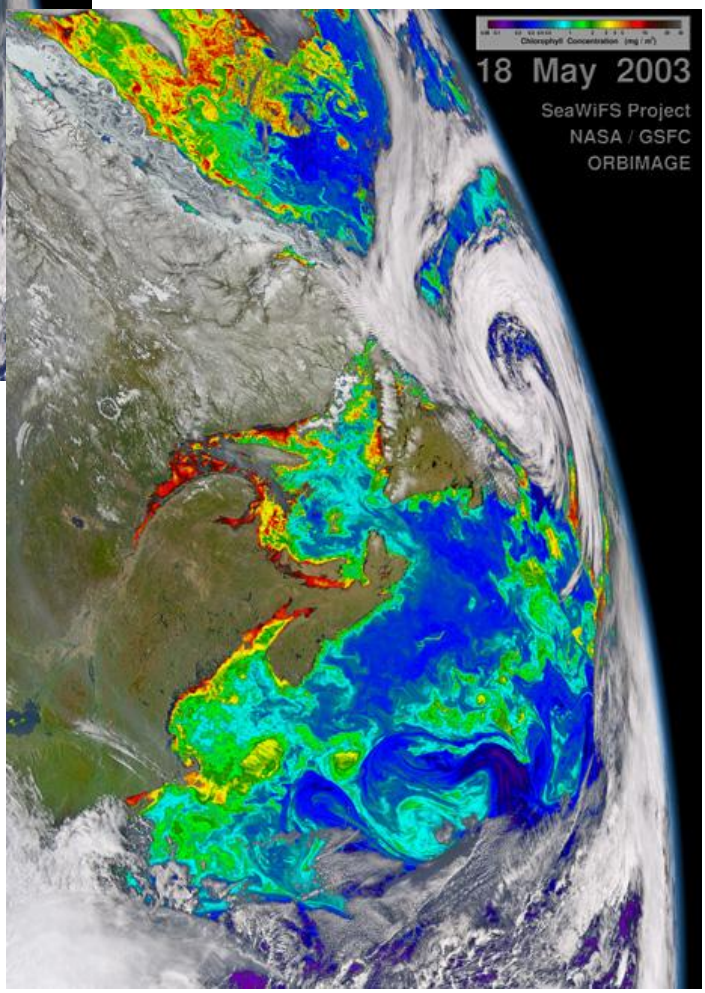
SCIENCE FOCUS: Geology and History

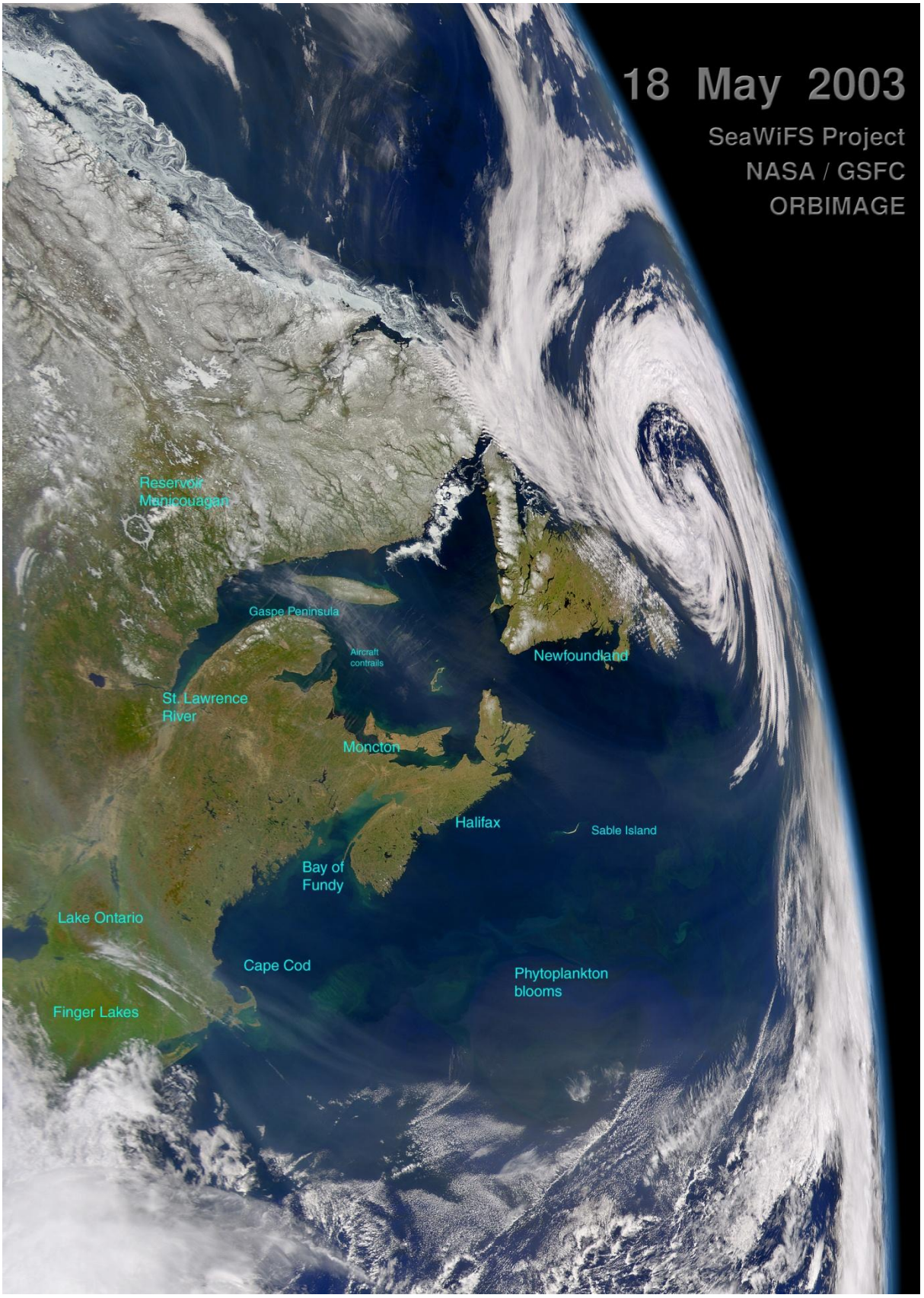
Springtime in the Maritimes, and Ghosts of the Past



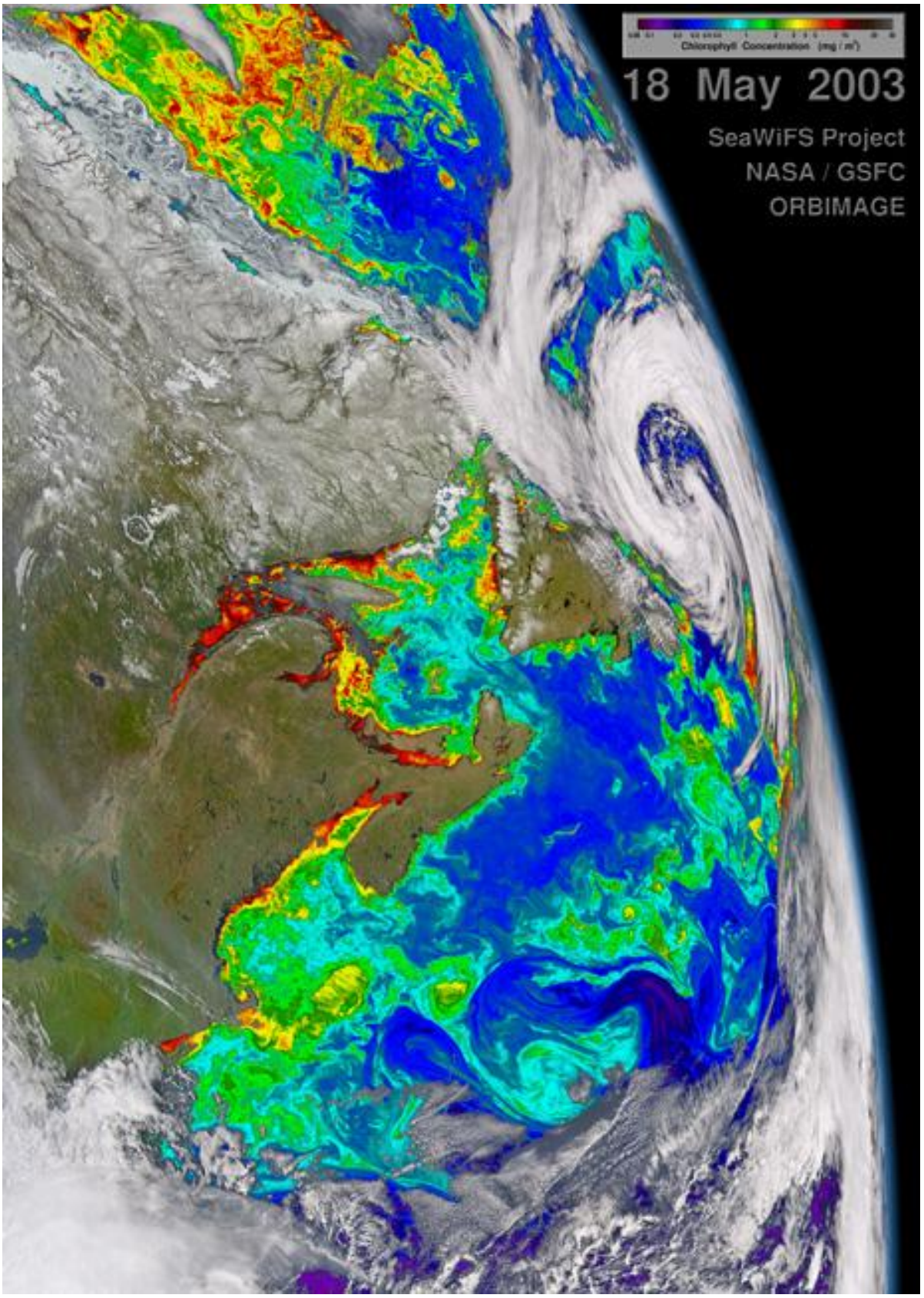
These two SeaWiFS images, processed from data acquired on May 18, 2003, provide a remarkable view of the Canadian Maritime provinces, as well as part of the northeastern United States. Although the primary concern of ocean color remote sensing observations is what is happening in the present—the day-to-day fluctuations of phytoplankton concentrations in the global ocean—this particular SeaWiFS image also provides a remarkable window on past events.



These ghostly reminders of past hours, days, seasons, or geological eras demonstrate the linkage between the climate and environment of the present day and the multitude of events which shaped the Earth in the past.



SeaWiFS Level 1A image of the Canadian Maritime provinces and northeastern United States, acquired May 18, 2003. Several features discussed in the text are labeled.



SeaWiFS composite Level 1A (land) and Level 2 (ocean) image of the Canadian Maritime Provinces and northeastern United States, acquired May 18, 2003.

Spring phytoplankton blooms

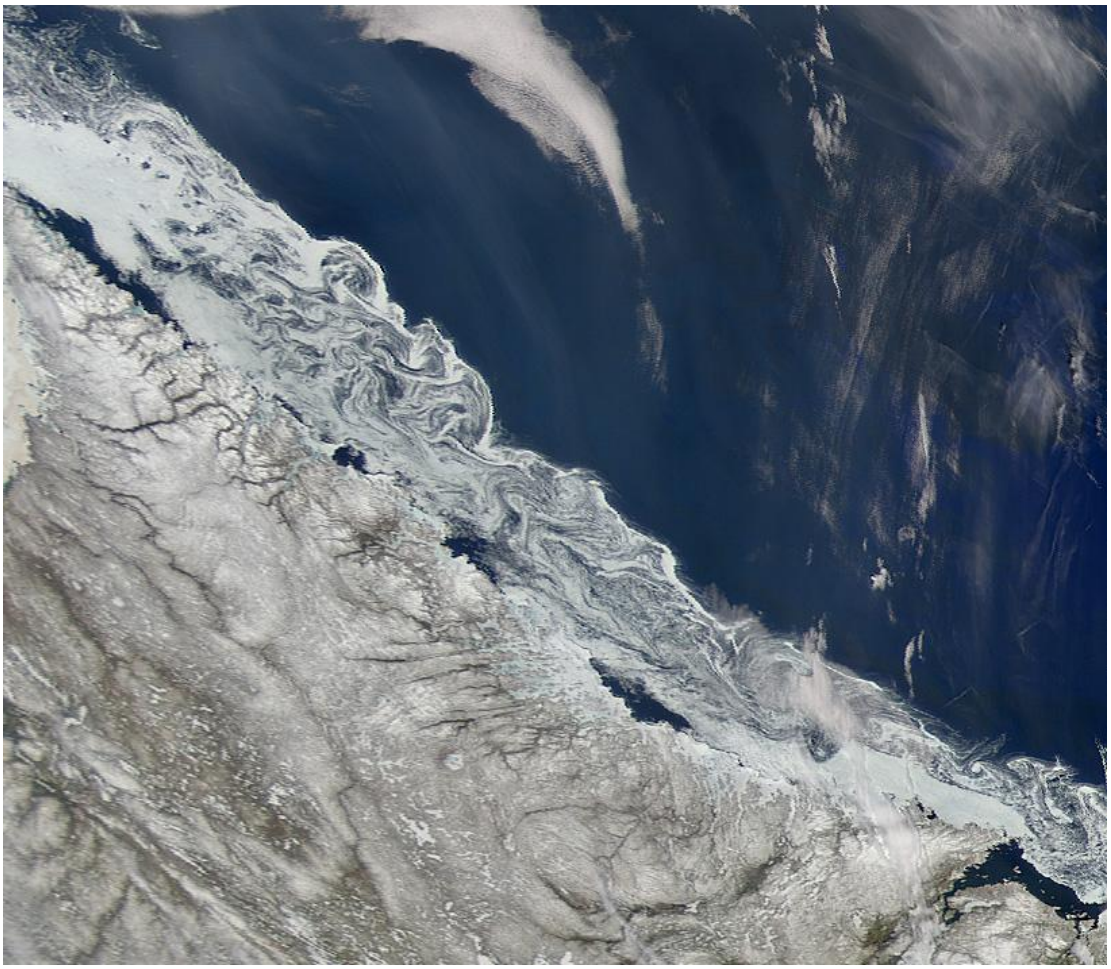
(Refer to the large composite image or labeled Level 1A image on the previous pages)

In May, the North Atlantic and the eastern coast of North America host explosions of phytoplankton productivity that mark the annual North Atlantic spring bloom. The SeaWiFS composite image vividly shows the swirling patterns of bloom activity along the Gulf Stream, and also displays eruptions of phytoplankton chlorophyll in the Gulf of Maine and the Gulf of St. Lawrence.

This spring abundance of phytoplankton relies on the increasing amount of sunlight and the "ghosts" of past generations of phytoplankton and zooplankton, now in the form of nutrients. After these organisms die, bacteria convert the dead organic matter that once formed their cells and bodies back into their primary constituents, notably carbon, nitrogen, and phosphorus. Over the winter, the concentrations of the vital nutrients nitrate and phosphate increase, and they fuel the phytoplankton in the spring as they responding to longer days and more intense light from the Sun.

Though it may be slightly macabre to contemplate how life in the ocean is linked to the death of previous inhabitants, the annual renewal of the North Atlantic spring bloom is one of the ocean's most powerful biological events.

Coastal swirls (ice and fog) on the Labrador Coast



The effects of winter linger on the frigid shores of the Labrador coast. Snow still covers the ground, while winds, waves, and coastal currents shape the coastal ice (and possibly overlying fog) into swirling vortices. In the large SeaWiFS Level 2 image, these vortices can also be seen in the offshore chlorophyll concentrations.

Pack ice and icebergs that float in the Labrador Current move southward, into the northwestern Atlantic Ocean. In 1912, the great cruise ship *Titanic* struck an iceberg southeast of Newfoundland, an iceberg that likely came from the Labrador Sea. For this reason, the U.S. Coast Guard and Canadian Ice Service continually map ice distributions using remote sensing.

Links

Ice Floes off Labrador

Satellite image of Newfoundland and Labrador

Labrador Sea Monitoring Program

Reservoir Manicouagan

From space, one of the easiest features to recognize on the east coast of North America is the circular Reservoir Manicouagan in Quebec. In this image, snow still covers the ice on the lake surface, while the snow has melted in the surrounding region, making it particularly easy to see. The reservoir lake outlines the boundaries of an ancient asteroid impact crater, dated to 212-214 million years ago. The reservoir is approximately 100 kilometers wide and is an important part of Quebec's hydroelectricity generation capacity.

Researchers in England reported the discovery of an ejecta layer 214 million years old, which might have been associated with the Manicouagan impact. Subsequent research discovered that there are actually five ancient craters, all formed during the Triassic period, that would have formed a linear pattern on the continents of the Earth at that time. It has been hypothesized that this impact event may have been responsible for the Carnian-Norian extinction event, an extinction event within the Triassic period that may have wiped out up to 80% of the species living on Earth at that time. Though the geologic dates of the Manicouagan impact and the Carnian-Norian boundary are not simultaneous, they are close enough to allow this scenario as a possibility.

Links

Reservoir Manicouagan from the Space Shuttle

Topography of the Manicouagan Crater, Quebec, Canada

Manicouagan Impact Structure

Bay of Fundy

Is this image boring? Well, this image, which shows Nova Scotia's famous Bay of Fundy, doesn't capture the dynamic changes in sea level that occur here daily, the site of the world's highest tides. And it doesn't show the tidal bore (a tidally-driven wave) that surges up several of the rivers that enter the bay, particularly near the northern terminus.

For many years, the tidal bore that rolled up the Petitcodiac River to Moncton was the most famous bore in the region, but a causeway has diminished its power, and the strongest bores are now generally in the Minas Basin on the eastern side of the bay. The bores, and the 10-12 meter changes in sea level that occur every day, are remarkable reminders of the invisible tug of the Moon's gravity on the ocean's surface.

In this image, Moncton is the starlike light area closest to the top of the image; the Petitcodiac River extends southeastward to the Bay of Fundy. The Minas Basin is the bay's northeastern extension. Sediments stirred by the incessant tidal cycle can be easily seen in the upper reaches of the bay and along the coast.

Links

The Highest Tides in the World

Petitcodiac River – Tidal Bore

The Hopewell Rocks

Bay of Fundy. com

Sable Island

The bright crescent seen in the image at left is one of the most unusual islands in the world, the isolated Sable Island. For centuries, Sable Island has been feared because of its noteworthy number of shipwrecks. Sable Island is near the Grand Banks fishing area and the Gulf Stream, and numerous fishing and trade vessels came to an end on its sandy beaches.

In addition, many Atlantic storms moving up the East Coast would push disabled ships toward Sable Island. The decaying skeletons of these ships still lurk in the shallows today. Sable Island is a nature reserve and is not inhabited by humans, but scientists come there every year to perform a variety of experiments. The only "large" year-round residents are the Sable Island horses, descendants of horses once owned by Acadians and procured by a Boston merchant when the Acadians were deported from Nova Scotia.

Sable Island itself is also a specter from the Ice Ages, the last glacial period in Earth's geologic history. It appears to mark the edge of the last large ice sheet that covered Nova Scotia, and may be a glacial moraine where the sediments moved by the ice sheets were deposited (due to the presence of the ice sheets, sea level was much lower than today). The sand that keeps Sable Island above water is derived from an immense sand bank on the continental shelf.

Links

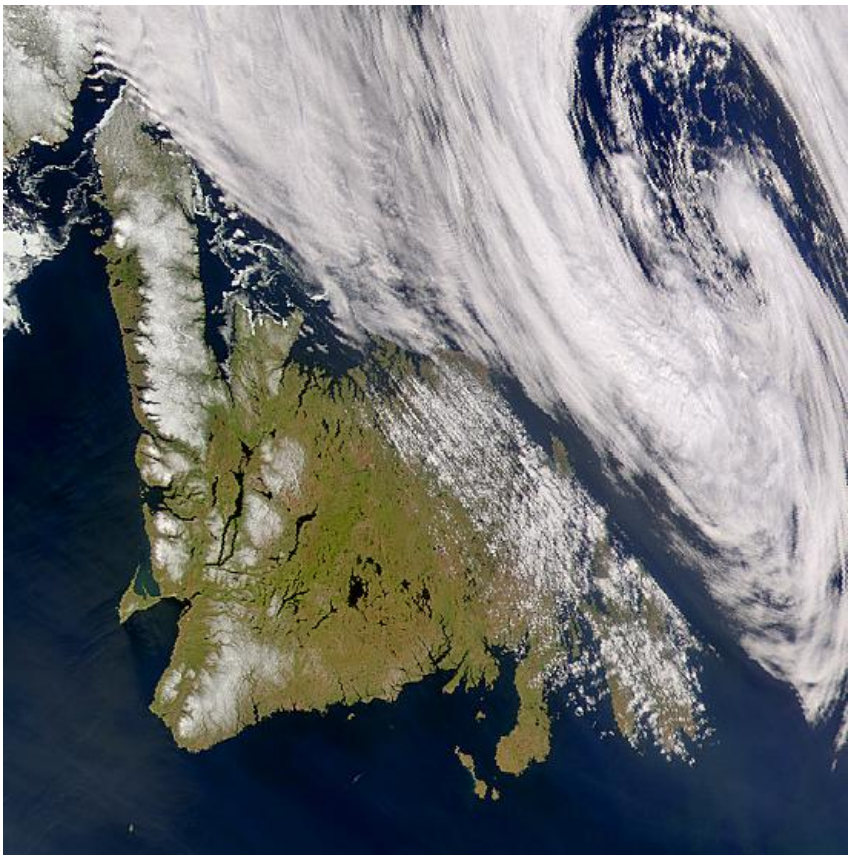
Sable Island Preservation Trust

The Allure of Sable Island

Sable Island: The Land of Legend and Mystery
(impressive pictures and an image of Sable Island from the Space Shuttle)

The Story of Glaciers in Maritime Canada

Newfoundland



When discussing Earth's geological history and the Canadian Maritime provinces, the island of Newfoundland should certainly not be overlooked. Newfoundland hosts an amazing variety of geological features, ranging in age from the Cambrian (with fossil thrombolites, similar to stromatolites) to land-locked freshwater fjords formed during the last glacial period. Of particular interest is Gros Morne National Park on the island's northern peninsula, which is a UNESCO (United Nations Educational, Scientific, and Cultural Organization) World Heritage Site. Among the many geological features of Gros Morne National Park is an ophiolite, a section of the ocean bottom that has been lifted above the ocean surface by tectonic forces.

Links

Newfoundland and Labrador Heritage - Landscape; Geological Landscape; Cold Ocean

Gros Morne National Park (Parks Canada)

The Story in Stone

Western Brook Pond

Aircraft contrails

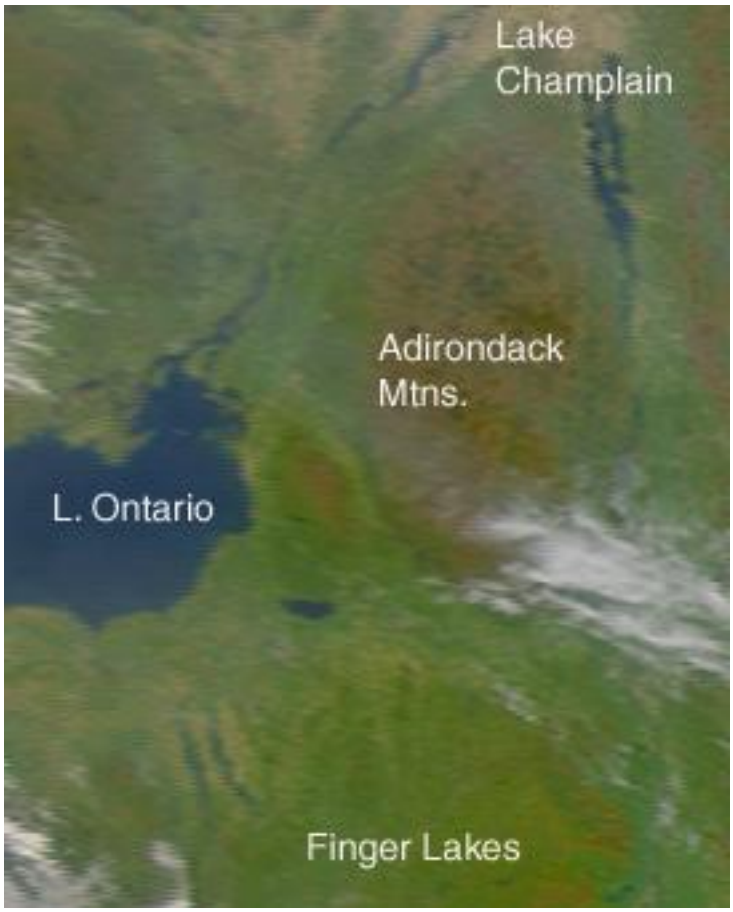
Much more modern ghosts than the ancient geology of Newfoundland are seen in this large area of aircraft contrails indicating planes flying the busy trans-Atlantic routes originating or terminating in New York City.

The large island at bottom right is Prince Edward Island, and the large elongated island at top center is Anticosti island, a provincial park. Southeast of Anticosti Island is the Gaspe Peninsula, a haven for nature and wildlife in northern Quebec.

In the days following the tragic attacks on the World Trade Center in New York City, the absence of aircraft contrails allowed atmospheric scientists to investigate the climate influence of these high altitude clouds.

Links
Jet contrails alter average daily temperature range
The Gaspe Peninsula, Canada

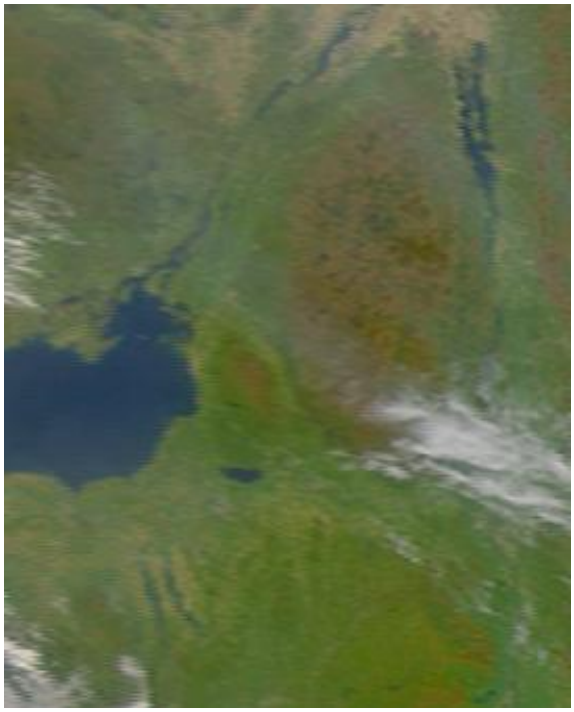
Upstate New York



This tour of the northeast coast of North America and the Canadian Maritimes ends in the bottom right corner of the image, which is slightly blurry at the edge of the SeaWiFS scanning swath. Question: What is the largest freshwater lake in the United States that is not one of the Great Lakes? Answer: Lake Champlain, which lies along the New York-Vermont border and has a small segment in Quebec. Lake Champlain, and the St. Lawrence River to the north, are also reminders of a dramatic period which took place at the end of the last glacial period. The glacial ice first deepened the valley that currently holds Lake Champlain. Then, as the Earth's temperature warmed and the ice sheets retreated, a giant lake of meltwater (Lake Vermont) formed in this area, behind dams of ice.

When the ice dams broke (a larger lake, Lake Agassiz in central Canada, drained into Hudson Bay), an immense volume of fresh water flowed into the north Atlantic Ocean, causing an abrupt shutdown of the ocean's thermohaline circulation pattern and a sudden interruption in the warming trend that lasted about 1,000 years. This period of time in geological history is called the "Younger Dryas" period. At about the same time, the retreat of the ice sheet allowed the ocean to flow into the Champlain Valley due to the depression of the Earth's surface caused by the weight of the ice. The combination of the Atlantic Ocean and Lake Vermont formed the "Champlain Sea". Over time, the Earth's surface rose again (a process called glacial rebound), and fresh water replaced the salt water from the ocean in Lake Champlain.

The glaciers of the Pleistocene Ice Age were also responsible for the formation of the Finger Lakes, seen in the lower left part of the image excerpt. The largest Finger Lakes and Lake Champlain are both very deep, in some places exceeding a depth of 400 feet.



Another important geological feature in this region are the Adirondack Mountains. The Adirondacks are visible in this image because their higher altitude means that winter still lingers on them, and the "spring greening" of their vegetation cover has not quite taken place. The Adirondacks are also notable for their geology, which consists of a granitic bedrock that was formed about 1.3 billion years ago, and uplifted as a "dome" about 15 million years ago, during the Miocene period. The uplift may have been due to a volcanic process similar to the formation of the Hawaiian Islands, a "hot spot", though in this case the molten rock only lifted the overlying rocks and did not break through to the surface.

The granitic bedrock of the Adirondacks makes the Adirondack lakes particularly susceptible to acidification due to acid rain. These lakes have very little buffering capacity to neutralize the acidity of rainfall created primarily by coal-burning electrical power plants in the Midwest. Due to the implementation of the Clean Air Act, power plant emissions have decreased and the acidity of the Adirondack Lakes is gradually being reduced. However, it may take several more decades before the lakes are fully recovered and fish return to their former haunts.

Links

Cracking abrupt climate change

Ancient superflood brought climate chaos

Natural History - Lake Champlain

Geological History and Glacial Formation of the Finger Lakes

Water quality in Adirondack lakes responding to acid rain regulations

Acknowledgements

This Science Focus! *article acknowledges the information provided by the authors of the Web sites linked above and thanks them for their assistance in the creation of this article.*